RCP Lube Oil Collection System
Current Trend Abstract
April 1999 (Revision 1)

Background

On January 3, 1973 a Reactor Coolant Pump (RCP) oil fire occurred at the Oconee Nuclear Station. The RCP lube oil fire resulted when a lower oil seal on the motor failed. Without any means of collecting the lost oil, the oil migrated undetected to the lower pump area. At this location large amounts of oil seeped into the RCS batt type insulating material which ultimately resulted in large amounts of smoke and ignition of the oil. Although the temperature of the RCS piping was well below the auto-ignition temperature of the oil, a fire occurred.

The NRC identified RCP lube oil as significant in terms of potential fires hazard in Appendix A to Branch Technical Position 9.5-1. They (NRC) specifically referred to the RCPs as an area in which some means was needed to control and collect the combustible oil in the event a compromise to the RCP oil system boundary was to occur. No specific compliance guidance was given in the BTP. Subsequent guidance required that collection systems be installed and maintained as part of the licensee's fire protection program (see the attached RCPLOCS Licensing Review).

The 1975 fire in the Cable Spreading Room of TVA's Brown Ferry plant, resulted in a heightened sense of awareness relative to the fire protection requirements at nuclear power facilities in the United States. This heightened sense of awareness resulted in the NRC reviewing the Fire Protection requirements and ultimately promulgating the requirements and guidance contained in Appendix R to 10CFR50. Configuration requirements for RCP Lube Oil Collection Systems was made more prescriptive and presumably reflected the NRC staff's thinking relative to a viable collection system. However, as prescriptive as the rule seemed to be, there remained many questions as to; a) what the specific concern was, b) what the Industry was expected to postulate relative to oil loss, and c) what means of collection were to be provided based upon the postulation.

The purpose of this white paper is to draft the scope of protection measures necessary to ensure adequate RCP Lube Oil Collection System configurations and provide a guideline acceptance criteria for the specific systems. This paper is intended as an information source for use by utilities in resolving RCPLOCS questions.

10CFR50 Appendix R

Section III.O of Appendix R states as follows:

> "The reactor coolant pump shall be equipped with an oil collection system if the containment is not inerted during normal operation. The oil collection system shall be so designed, engineered, and installed that failure will not lead to fire during normal or design basis accident conditions and that there is reasonable assurance that the system will withstand the Safe Shutdown Earthquake.

> "Such collection systems shall be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in reactor coolant pump lube oil systems. Leakage shall be collected and drained to a vented closed container that can hold the entire lube oil system inventory. A flame arrestor is required in the vent if the flash point characteristics of the oil present the hazard of fire flashback. Leakage points to be protected shall include lift pump and piping, overflow lines, lube oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and lube oil reservoirs where such features exist on the reactor coolant pumps. The drain line shall be large enough to accommodate the largest potential oil leak."

Many questions have been raised relative to the wording contained in this section, for example, " will not lead to a fire under normal and design basis accident conditions'*. Does this mean that the licensee must ensure that a fire will not occur? Does it mean that Appendix R requirements are not applied during heat up? After all, heat up is not regarded as normal operation.

Scope

The second paragraph of III.O provides specific guidance relative to possible leak sites. Is this all-inclusive or just a representative example? If the lube oil piping is designed to seismic criteria does the collection system need to he designed to seismic criteria also? This paper will look at previous guidance provided by the Staff on these issues and will attempt to present a responsible industry position. A preliminary attempt will also be made to assess each of the points presented in paragraph 2 of III.O and apply what is written to those conditions, which actually exist in the field. Potential leak sites, which are common to all RCPs, will be addressed. Finally oil loss through uncollectable sites, and typical pump bay accumulations will be discussed.

Assumption

- It is assumed that licensees maintain a practice of safe operation.
- RCPs are maintained in a manner consistent with the manufacturers recommendations.
- Intentional overfilling of RCP reservoirs in an effort To extend the period between filling events is not regarded as a sound method of operation and is not endorsed by this committee.
- An overfilled RCP is not regarded as being operated within normal design and operating parameters and may represent a condition, which was not considered or represented in design basis submittals. It is contested that attempting to address this problem through an enhanced RCP lube oil collection system does not address the real problem of operating the RCP outside its design and operating parameters.
- This analysis evaluates systems and components, which are either continually or intermittently running during normal plant operating conditions both from the system and component perspective. This is consistent with the rule as written and is regarded as sound design and operating practice.
- RCP drive motors are large rotating devices that consume lubricant. This consumption may result in an accumulation of oil in the RCP bay and/or small pools in and around the motor. This condition does not necessarily present and unsafe fire hazard and should be evaluated on a case by case basis.

Evaluation

Unpressurized Leakage Sites

Examples of unpressurized leakage sites may be represented by such configurations as the RCP reservoirs and any appurtenance, which penetrates the reservoir boundary such as oil fill lines and temperature thermocouples. However, it is contended that a leakage's site is created only at those points below maximum oil level maintained in the reservoir. Therefore, oil fill lines (local or remote) which contain residual oil during normal operation do not represent credible leakage sites. Further argument regarding oil fill lines:

- The period for which oil is contained within the upper portion of the oil fill line is considered a snapshot in time. As a result it is considered highly improbable that a loss of oil will occur during this fill period.
- Given the amount of oil transferred via this method, typically less than 5 gallons, it is contended that if a leak were to occur in the line, it would result in an immeasurable amount of oil lost and thus would be regarded as inconsequential in terms of the fire hazards presented.
- Projection of leakage on low pressure systems as a result of the Torcelli Effect (i.e. head pressure imposed on a confined liquid) should be considered when selecting a protection scheme.

In summary, potential unpressurized leak sites are regarded as those pipes, fittings, plugs, and thermocouple locations which are expected to maintain the oil reservoir boundary and loss of this oil boundary will result in the loss of reservoir oil level.

Pressurized Leakage Sites

Pressurized leakage sites are defined as those locations in the lube oil system which are maintained at a pressure above that which is created by gravity. Examples of pressurized piping are oil lift pump piping, and lube oil piping associated with the lube oil cooler. The degree of leakage collection required is based upon the expected failure modes of the piping being analyzed and the amount of pressure maintained 3t the boundary. Lift oil pump and piping although typically not running under normal operating or design basis accident conditions, does operate at moderately high pressure levels and provisions shall be provided for those fittings and connections where oil spray is a reasonable expectation. Encapsulation shielding is typically an effective method for mitigating the effects of oil spray.

Lube oil coolers and the piping to and from them are also potential leak sites. These systems typically operate in pressure ranges of between 10 to 20 psi. Connections are generally flanged or welded. Although the flanged connections have been known to leak oil, the type of leakage normally experienced by these fitting failures may be categorized as a "weeping" of oil at the interface of the flanged component. The expected leak rate for flanged connection will be discussed in detail below under "Types of Connections". Schedule 40 pipes in the sizes ranging from 2.5" to 4" are typical for lube oil cooler installations. ASME Section 9 welds are used for connections other than the flanged configurations mentioned above.

RCPLO systems are substantially designed including seismic load considerations. Typical working loads are the minor vibrations inherent to the RCP motor. RCP lube oil coolers and associated piping are not subjected to substantial forces or movements and thus compromise of the welded joint is highly

improbable. Due the nature and speed of the oil as it passes through the lube oil cooler and associated piping, wall thinning due to erosion is considered incredible and not evaluated further.

To summarize, the lift oil piping is regarded as a pressurized leak site in which spray oil can result and as a result, provisions shall be provided to ensure all oil ejected from a compromised oil pressure boundary associated with the lift oil pump and piping is shielded and diverted to collection system piping. Unlike the lift oil piping, the pressures typically associated with the lube oil cooler is sufficiently low so as not to warrant any additional measure apart from the need to collect random drips of oil.

Seismic Considerations

Generic letter 86-10 addressed the issue of lube oil systems which have been designed to Seismic Criteria. The guidance provided in this document stipulates that if the RCP lube oil system is capable of withstanding a SSE, then the oil collection system need only be capable of controlling normal system leakage. Normal system leakage should he defined as the total motor inventory. The exemption process should be pursued for RCPLOCS which are not seismically designed.

Types of Connections

There are four types of connections typically found on an Reactor Coolant Pump motor lube oil systems: 1) flanged, 2) screwed, 3) welded and, 4) compression fittings. This section will evaluate each type of connection and its typical use on an RCP motor lube oil system.

- Flanged connections are typically found on the RCP lube oil cooler piping at the interface of the lube oil cooler and lube oil reservoir. As mentioned previously, the typical operating pressure for the lube oil coolers is relatively low, between 10 and 20 psig, depending upon the RCP manufacturer. The flanges are typically 150 lb. ANSI standard flanges which are rated at 235 psi for temperatures up to 100 degrees F provided the materials conform to ANSI B 16.5 specified carbon steel material groups. Flanged connections may also be employed on high pressure lift pump output piping and should be afforded protection accordingly.

- Screwed connections are generally found on the return line from the reservoir which would see no more than the static pressure of the reservoir level (no more than 5-10 psig). The connections, if fabricated in accordance with ANSI B1.20.1 (or earlier std's) should withstand the same pressure as the fittings and pipe which connects them. The pipe, which is generally schedule 80, would be rated at greater than the flanges described above (greater than 2000 psi @ 650 degrees F vs. 235 psi described above). Screwed fittings are also installed in the lift oil circuit inside the oil reservoir. These fittings are 3000 lb. ANSI fittings of small diameter which are rated for greater pressure than either the lift oil or normal recirculating oil pressures. Screwed fittings may also be utilized on pressure and level indicator devices.

- Welded connections are found at certain interfaces such as between the reservoir and supply and drain lines and on the lift oil pressure circuit. If properly welded the strength of the weld metal will be greater than that of the weakest component being welded and should not become a source of leakage. Therefore, these fittings should be excluded from further consideration as a 'potential leak point*.

Compression fittings are typically found in locations such as the oil pressure communication circuit and some of the lift oil circuit. The tubing typically has a working pressure rating well in excess of 3000 psi. The fittings arc typically SWACELOK type brand and are rated by the OEM at 7800 psi at the male end and 5300 psi at the female end. The installation of the fittings is such that proper compression occurs at the fitting and pressure retention is maintained.

Protection Schemes

Protection schemes are passive components intended to ensure that any RCPLOS leakage is adequately confined, diverted, and retained remotely from ignition sources. Methods of ensuring that potential oil leakage sites are adequately protected by include the use of drip pans, spray shields, diversionary dikes, component/system enclosures and, combinations of all the above. Total enclosure of components associated with unpressurized systems is not required as the expected leakage form these areas would be captured by the use of drip pans.

Comparison of Industry Events and the regulation which followed

As discussed previously, several events have occurred which caused both the industry licensees and the regulators to re-evaluate the overall effectiveness of the RCPLOCS and the regulations which required them. It should be noted that none of these incidents occurred as a result of a lack of regulation but rather how the regulations were applied. Most notable of the industry events was that which occurred in 1975 at the Oconee Nuclear Station. This event was significant in that a large quantity of oil was released and subsequently absorbed by the porous insulation on the RCS Hot Leg piping below. The NRC reviewed the results of the Oconee event and identified the RCP Lube oil as a significant fire hazard if not properly designed for. As a result, staff specifically called out RCP oil as a significant hazard and licensees were then required to address the hazard associated with the lube oil system as part of their fire protection program.

On May 29, 1980, Appendix R to 10CFR50 was issued as a proposed rule for fire protection in operating nuclear power plants. Section III.0 dealt specifically with the subject of RCP Lube Oil Collection Systems. It is contended based upon the fire events which occurred prior to the rules promulgation that the concern of the RCP lube oil system was not that of incidental drops or droplets of oil, but rather that the entire lube oil inventory would not be contained given a failure in the oil boundary such as the event which occurred at Oconee. The position is reinforced by a decision to grant an exemption to Big Rock Point for the installation of a lube oil collection system on the basis that the pump contained a maximum 31.75 gallons oil and as a result the maximum postulated temperature rise was less than 164 degrees. In 1982 the NRC again granted an exemption to La Crosse for 15 gallon of uncollected lube oil. The basis stated that only a small fire would be postulated and thus would not affect safety related equipment. It is apparent by review the concern on the part of the staff at the time focused on large fires spreading throughout containment.

Recent events at both Haddem Neck and ANO have resulted in events that were not the result of system or components failure but rather an inadequate design at Haddam Neck and a construction (-welding) and inspection error at ANO. For Haddam Neck the failed component was a PVC fitting. ANO had an inadequate weld both resulted in a oil soaked lagging fire. Both events need to be evaluated in detail and actions taken to prevent reoccurrence. However, these two singular events must be kept in perspective

and discretion used to prevent applying generic corrective action. For example, in the case of the ANO fire, it was determined from examination that the fire was the direct result of an improperly applied weld, not a properly performed weld which ultimately failed.

In the case of Haddam Neck, the fire was the direct result of a failed cracked PVC fitting rather than a typically used metallic fitting. A strength analysis of both materials will clearly demonstrate that the metallic fitting is far superior in terms of fracture resistance to that of the PVC fitting. In conclusion, comparisons of the strengths associated with metallic fittings and pipe vs. that of PVC is not consistent with sound engineering analytical practices.

The fire which occurred at ANO was the result of a very specific set of events. All of the events were preventable and had any one not occurred the fire would not have taken place. The III.O requirements for the RCP lube oil collection system have been installed and designed to account the passive equipment or component failure not for manual shortcoming as exemplified by the ANO. In performing a root cause analysis of the fire, many barriers related to prevention were broken and several opportunities were presented to prevent or mitigate the fire. Although the ultimate cause of the fire was attributed to an substandard welded connection, caution should be exercised before considering all welded connections as potential leak sites. It has been demonstrated previously that properly performed welds will fail only when subjected to cyclic fatigue factors or stresses in excess of their rated designs.

As a final note relative to the Haddam Neck and ANO events, in both cases the fire was the result of oil soaked lagging which in turn resulted in the auto-ignition temperature of the oil being reduced to a temperature lower that on which it was dropped. At this temperature auto-ignition occurred. Had the oil been deposited upon non-absorptive reflective metallic insulation the fires would not have occurred.

Conclusion

Very specific sets of circumstances are required to initiate an RCP lube oil fire. The uncontrolled release of lube oil must come in contact with a heat source of sufficient magnitude to cause ignition of the oil. In the cases described above, the auto-ignition temperature was dropped due to oil soaked lagging, a common industrial fire scenario. However, typically speaking, the absorptive type insulating blankets have been replaced with insulating systems which will eliminate the lagging type fire scenario.

The ANO and Haddem Neck events not withstanding, and qualitatively evaluated in their proper perspective, significant performance-based evidence has been obtained since the Oconee event in 1975 to established a set of realistic criteria for both the performance of RCPs and their associated lube oil collection systems. To consider all threaded connections (regardless of material type) potential leak sites due to the physical failure of a PVC threaded connection would not be consistent with engineering failure analysis criteria.

Administrative work and construction controls should be considered as mechanisms which may be used to prevent leaks from occurring. For example, when welded pipes are used in a RCP lift oil pump system, post weld test such as a hydrostatic pressure test may be performed to ensure weld integrity. Upon system startup an ISLT (In-Service Leak Test) may be performed to verify system integrity. Had these same precautions been used in the ANO event, it can be concluded the fire would not have occurred. By precluding the use of PVC fittings on RCPs, the most common type of RCP lube oil system failure and the cause of the Haddem Neck fire, additional leak sites may be eliminated.

Finally, Appendix R, Section III.O requires that RCP fires be prevented. It is not regarded sound engineering practice to assume complete fire prevention nor is complete fire prevention assumed in the balance of Appendix R. Rather, it is the responsibility of the fire protection engineer to provide a system or set of requirements to prevent the fire from occurring, mitigate the effects of a fire should one occur, and finally minimize the damage which results from a fire which has occurred. This approach is consistent with the defense-in-depth philosophy of fire protection programs in place in the industry. This philosophy has been tremendously successful in the nuclear industry since the 1975 Brown's Ferry Fire.

Significant operating history exists which provides the necessary guidance to support alternative approaches to RCP lube oil hazards. It is proposed to revise the guidance provided in Generic Letter 86-10 to reflect the evidence assembled over the past 22 years of operating history. Enough evidence exists for the fire protection engineer to assess their specific RCP installation and make specific recommendations for their protection. All factors must be considered in this assessment including the types of connections used, the post maintenance inspections, and the sources of ignition. A complete fire hazards analysis is appropriate for the protection of Reactor Coolant Pumps.

TABLE 1 - EVOLUTION OF RCP LUBE OIL COLLECTION SYSTEM REQUIREMENTS

10 CFR 50, Appendix R, Section III.O

Reactor Coolant Pump Lube Oil Collection Systems

Licensing Review

April 1999 (Revision 1)

Table of Contents

1.0 **Purpose**

The purpose of this Licensing Review is to establish the original intent for installation of Reactor Coolant Pump (RCP) lube oil collection systems and to identify the methods of complying with the original regulatory requirements (plant-specific licensing positions) from various licensees. The results of this Licensing Review will he compared with recent NRC positions and regulatory activities related to RCP lube oil collection systems to determine if there are any subtle contradictions in recent regulatory interpretations.

2.0 Regulatory Requirements and Guidance Documents

Appendix A to Branch Technical Position (BTP), Auxiliary Power and Chemical Systems Branch (APCSB), 9.5-1, Section D.2.(a) (3):

> "Safety-related systems should be isolated from combustible materials. When this is not possible because of the nature of the safety system or the combustible material, special protection should be provided to prevent a fire from defeating the safety system function. Such protection may involve a combination of automatic fire suppression, and construction capable of withstanding and containing a fire that consumes all combustibles present. Examples of such combustible materials that may not be separable from the remainder of its system are:...(3) Reactor coolant pump lube oil system."

10 CFR 50, Appendix R, Section III.O

> "The reactor coolant pump shall be equipped with an oil collection system if the containment is not inerted during normal operation. The oil collection system shall be so designed, engineered, and installed that failure will not lead to fire during normal or design basis accident conditions and that there is reasonable assurance that the system will withstand the Safe Shutdown Earthquake.
>
> "Such collection systems shall be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in reactor coolant pump lube oil systems. Leakage shall be collected and drained to a vented closed container that can hold the entire lube oil system inventory. A flame arrestor is required in the vent if the flashpoint characteristics of the oil present the hazard of fire flashback. Leakage points to be protected shall include lift pump and piping, overflow lines, lube oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines, and lube oil reservoirs where such features exist on the reactor coolant pumps. The drain line shall be large enough to accommodate the largest potential oil leak."

NRC Internal Memoranda firm J. A, Olshinski to D.G. Eisenhut dated 3/15/83 and R.H. Vollmer to D.G. Eisenhut dated 4/1/83, Subject: Oil Collection System for Reactor Coolant Pumps, Florida Power and Light Company, St. Lucie Unit 2-Docket No. 50-389

> The oil collection system provided for the RCPs in St. Lucie Unit 2 is connected to a drainage system which discharges into a tank sized to accommodate the quantity of oil from a single coolant pump. This was approved by the NRC in an SER dated October 1981. Because Section III.O requires that the oil collection system accommodate the oil from all primary coolant pumps, the failure to provide a system with sufficient capacity was an NRC

inspection finding (Region HI Report Nos. 50-315/82-08 and 50-316/82-08) for Davis-Besse. These inconsistencies prompted an NRC re-review of the lube oil collection system.

The NRC has found acceptable collections system which have oil from all pumps drain to one container which has the capacity to hold oil from one pump with margin. This has been found acceptable provided the container is located within the containment such that if the container overflows (due to draining form more than one pump), the oil presents no threat to safety components within the containment or to the plant's capability to cope with other design basis events. The staff's position which meets the guidelines of Section III.O is as follows:

1) One or more tanks need to be provided with sufficient capacity to collect the total lube oil inventory from all reactor coolant pumps drain to the container; or
2) One or more tanks need to be provided with sufficient capacity to hold the total lube oil inventory of one reactor coolant pump with margin if the tank(s) are located such that any overflow form the tank(s) will be drained to a safe location where the lube oil collection will not present an exposure fire hazard to or otherwise endanger safety related equipment; or
3) Where the RCP lube oil system is shown to be capable of withstanding the safe shutdown earthquake (SSE), the container size which satisfies 2 above is deemed acceptable to protect only against possible leakage due to random leaks in the lube oil system.

For pumps where the lube oil is contained entirely within the pump casing, an oil collection system may not be required and an exemption to Section III.O may be granted.

Rulemaking Issue Information dated 7/5/83, Subject: Fire Protection Rule for Future Plants (SECY) 82-267

This report is a summary of licensee fire protection exemption requested and the safety significance of the requests. The report also provides a summary of research results and a discussion of the impact these results have on the staff's view of fire protection requirements.
Section 1.6: Section III.O requires an oil collection system to prevent oil leaks from causing an extensive fire inside containment. Where oil collection systems were not provided, exemptions were granted for the following alternatives:

a. The oil is entirely contained within the electric motor housing; or
b. The oil inventory was reduced to 15 gallons per pump or replaced with a nonflammable fluid

Each of these alternatives mitigates the potential hazards to an equivalent extent as the collection system.

Information Notice 84-09, "Lessons learned from NRC Inspections of Fire Protection Safe Shutdown systems (10 CFR 50, Appendix R), Attachment 1, Section XII. RCP Oil collection Systems

At some facilities, the lube oil collection systems for me reactor coolant pumps were not sized to accept the entire lube oil inventory from all reactor coolant pumps without overflow. This does not protect against the consequences of simultaneous failure of more than one lube oil system during a seismic event.

Section 11I.O, Oil Collection Systems for Reactor Coolant Pumps, is written for a single pump. The collect container is required to hold the entire inventory of the oil system of

the pump. It follows that if additional pumps arc present they would each be provided full collection capacity, there are usually from 2 to 4 reactor coolant pumps in a plant. The oil inventory of one large pump is approximately 275 gallons. Some licensees have provided several containers connected in parallel for each pump.

The NRC staff position on the capacity of a reactor coolant pump oil collection system which meets Section III.O of Appendix R to 10 CFR 50 is:

> One or more tanks need to be provided with sufficient capacity to collect the total lube oil inventory from all reactor coolant pumps draining to the container.

Alternatives which have been found acceptable under the exemption process are:

1. One or more tanks need to be provided with sufficient capacity to hold the total lube oil inventory of one reactor coolant pump with margin if the tank(s) is/are located such that overflow from the tank(s) will be drained to a safe location where the lube oil will not present an exposure fire hazard to or otherwise endanger safety-related equipment; or

2. Where the RCP lube oil system is shown, by analysis, to be capable of withstanding the safe shutdown earthquake (SSE) (eliminating the consideration of simultaneous lube oil system ruptures from a seismic event), protection is required for random leaks at mechanical joints in the lube oil system (e.g., flanges, RTD connections, sightglasses). Alternative methods of protection may be deemed acceptable for such designs. In RCP lube oil collection systems of such designs, one or more tanks need to be provided with sufficient capacity to hold the total lube oil inventory of one reactor coolant pump with margin. Because protection is required only against possible leakage resulting from random leaks from the one pump at a time, any overflow from the tanks need not be considered; or

3. For those pumps where the lube oil is contained entirely within the pump casing, an oil collection system may not be required, provided it can be shown that there are no potentially significant leakage points.

Generic Letter 86-10, "Implementation of Fire Protection Requirements"
Enclosure 2, Section 6.0

Question 6.1: *"If the reactor coolant pump lube oil system and associated appurtenances are seismically designed, does the lube oil collection system also require seismic design? Is an exemption required?"*

Where the RCP lube oil system is capable of withstanding the safe shutdown earthquake (SSE), the analysis should assume that only random oil leaks from the joints could occur during the lifetime of the plant. The oil collection system, therefore, should be designed to safely channel the quantity of oil from one pump to a vented closed container. Under this set of circumstances, the oil collection system would not have to be seismically designed.

An exemption is required for a non-seismically designed collection system. The basis for this exemption would be that random leaks are not assumed to occur simultaneously with the seismic event, since the lube oil system is designed to withstand the seismic event. However, the Rule, as written, does not make this allowance."

Question 6.2: *"It would appear that a literal reading of Section III.O regarding the oil collection system for the reactor coolant pump could be met by a combination of seismically designed splash shields and a sump with sufficient capacity to contain the entire lube oil system inventory.. If the reactor coolant pump is seismically designed and the nearby piping hot surfaces are protected by seismically designed splash shields such that any spilled lube oil would contact only cold surfaces, does this design concept conform to the requirements of the rule?"*

If the reactor coolant pump, including the oil system, is seismically designed and the nearby hot surfaces of piping are protected by seismically designed splash shields such that any spilled lube oil would contact only cold surfaces, and it could be demonstrated by engineering analysis that sump and splash shields would be capable of preventing a fire during normal and design basis accident conditions, the safety objective of Section III.O would be achieved. Such a design concept would have to be evaluated under the exemption process. The justification for the exemption should provide reasonable assurance that oil from all potential pressurized and unpressurized leakage points would be safely collected and drained to the sump. The sump should be shown capable of safely containing all the anticipated oil leakage. The analysis should verify that there are no electric sources of ignition.

Inspection Procedure 64100, "Past-fire Safe-Shutdown Emergency Lighting and Oil Collection Capability at Operating and Near- Term Operating Reactor Facilities"

Section 02.04, "Section III.O, Oil Collection Systems for Reactor Coolant Pumps

a. Review the drawings and calculations for the oil collection system to verify that all potential leakage points in the reactor coolant pump oil system have been contained and the drain line(s) have been sized to accommodate the maximum leak rate.

b. Verify that the oil collection system components have been designed so that there is reasonable assurance that they would withstand the safe shutdown earthquake (see Section III.0 of Appendix R) or that the RP lube oil system and associated appurtenances are seismically designed to withstand the safe shutdown earthquake and that the licensee has submitted and NRR has approved an exemption for a non-seismically designed oil collection system.

c. Verify that either the oil has a sufficient high flashpoint to prevent ignition of the oil by any equipment in the area or the tank vent has a flame arrester installed.

d. Verify that the licensee has a surveillance procedure for the oil collection system and has implemented the procedure. The following should be included in the procedure:
   1. periodic testing of the remote level indication (if installed)
   2. periodic visual examination of the oil collection system piping and tank

e. Verify that the collection tank is a dosed, vented tank and has sufficient capacity to simultaneously collect all the oil from the reactor coolant pumps (upper and lower lube oil system), or sufficient capacity to collect the oil from one reactor coolant pump and such design as to direct overflow to a location which does not present a fire hazard. For the latter case, refer to applicable SERs for the specific configuration required.

f. Inspect the reactor coolant pump oil collection system to verify that it was installed as indicated by the drawings. If seismically designed, verify all piping is seismically supported.

Information Notice 94-58, "Reactor Coolant Pump Lube Oil Fire"

The NRC issued this Info Notice to notify licensees of fire incidents involving RCP lube oil in Haddam Neck Plant and Millstone Nuclear Power Station (July 1994). In both events, the NRC observed that lube oil had leaked from the piping and was nor collected in the lube oil collection system. In PWRs, each RCP motor typically contains between 530 and 830 liters (140 and 220 gallons) of oil. Oil leaking from the lube oil system may come in contact with either (1) surfaces that are hot enough to ignite the oil, or (2) an electrical source of ignition. An adequately designed, installed, and maintained oil collection system is necessary to contain any oil released because of leakage or failure of the lubrication system and to minimize fire hazards by draining the oil to a safe location.

In Haddam Neck, a fire resulted in oil leaking from a cracked threaded PVC fining. The oil leaking from the cracked fitting was not properly collected and was routed away from high velocity cooling air, which blew the oil on the insulation on the pump casing and pipe. The cooling air came from the RCP motor and area ventilation system. The oil-soaked insulation ignited due to the high temperature of the RCS.

In Millstone Unit 2, oil bar! dripped from the trips of the "A" and "D" pump motors, coating the outside of the motors. Most of the oil was collected by the drip pans. However, some of the oil the dripped from the "A" pump was not contained. An NRC inspector examined the collection system and the area around the RCPs, and noticed that various equipment around the "A" RCP was coated with a film of oil and estimated that several gallons of oil had collected in various areas outside the oil collection system. The inspector also noted that the portions of the lube oil systems were outside the oil collection system and that the collection system piping did not appear to be large enough to accommodate the largest potential oil leak.

3.0 **Review**

Based on reviewing Section III.O of 10 CFR 50, Appendix R, and the technical basis for the rule, the intent of an RCP lube oil collection system is to protect a large fire hazard inside noninertcd containment from affecting safety-related equipment in the event of a fire. The NRC is concerned with a resulting fire that could be large resulting in an increase in containment air temperature and generation of large amounts of smoke. In addition, access to the fire would be delayed because of the time to enter containment. These conditions could affect operability of safety-related equipment inside containment. Therefore, the oil collection system is expected to confine any oil discharged from the pump motors due to leakage or failure of the lubrication system to a safe location. Because the leakages or failure of the system could be random or seismically induced, Section III.O also requires the lube oil collection system to be qualified to withstand a Safe Shutdown Earthquake (SSE).

Although the guidance provided in Appendix A to BTP (APCSB) 9.5-1 and the Appendix R rule does no: postulate a fire (or fire protection system failures) to occur concurrent with other plant accidents or the most severe natural phenomena, historical data has shown that most fires associated with earthquakes are due to failure of piping or tanks of flammable gases or liquids. Thus, because the RCP lube oil is a highly flammable liquid and is contained in large volumes in containment (about 140 to 220 gallons per reactor coolant pump motor), the NRC is concerned with a large fire affecting safety-related equipment as a result of an earthquake. Earlier versions of the rule considered an automatic fire suppression system to adequately protect the hazard. However, due to possible failure of the fire water supply system during the seismic activity and possible unacceptable damage to

safety-related system from the burning oil before the suppression system is actuated, the suppression system was deleted as an alternative to the collection system. Table 1 provides the evolution of Section III.O and the technical basis for the regulation. Table 2 provides a list of plants which have an exemption or deviation from the NRC and/or have had recent licensing activities associated with the RCP lube oil collection system. Because of recent fire events and regulatory activity involving Section III.O, both the NRC and licensees are re-evaluating RCP lube oil collection systems to determine if the systems are designed and maintained as intended by the Rule and/or approved exemptions/deviations.

This review is based on data gathered from regulatory guidance documents and past NRC and licensee positions. This review also evaluates acceptable lube oil collection system designs and licensing options with respect to compliance with Section III.O requirements. The intent of some specific sections of the rule have re-surfaced and are discussed further below.

Leakage Points

Section III.O is very specific in the types of pressurized and unpressurized leakages to consider in the lube oil collection system. Specifically, the leakage points to protect are the lift pump and piping, overflow lines, lube oil coolant, oil fill and drain lines and plugs, flanged connections on oil lines and lube oil reservoirs where such features exist on the reactor coolant pumps. Therefore, lack of protection for any of these leakage points would require an exemption or deviation to the requirement. Exemptions were granted or requested to ANO-2, TMI Unit 1 and Waterford 3 for not including the remote oil fill lines as part of the lube oil collection system. Crystal River 3 was granted an exemption from not protecting leakages from four potential leakage sites. The safety evaluation for the leakages from these unprotected points have determined that a potential fire would be small and would not affect safety-related equipment. Ft. Calhoun was granted an exemption for not providing an oil collection system for approximately lour gallons of oil in the lower reservoir. The technical basis for Ft. Calhoun's exemption was due to a fire hazards analysis demonstrating that the ability to safely shutdown the plant was not affected if a fire occurred due to leakage of the 4 gallons of oil.

Davis-Besse recently submitted an LER which reported the lack of protecting leakages from the remote oil fill lines as being outside the requirements of Section III.O. Corrective actions are still under investigation. In addition, Information Notice 94-58 identified a concern with oil leaks (one due to a failure of a PVC coupling, and the another due to leaking from the top of the RCP motors) not being contained within the lube oil collection system. For one case (Haddam Neck) oil-soaked insulation ignited due to the hot RCS piping. About 40 gallons was determined to have leaked onto the insulation. Both plants received a Severity Level IV violation.

In another recent event (Oct. 1995), a fire in ANO-1 occurred to ignition of a fine mist of oil which was sprayed onto hot RCS piping due to a cracked weld. This event identified a concern with oil, when subjected to a "fine mist" configuration, which can ignite at a much lower temperature than the estimated flashpoint (˜400 F)and auto-ignition temperature (˜670 -690 F). For this event, ANO received a Severity Level IV violation for failure to have the collection system contain all oil leaks due to the failed weld.

The above recent licensing activities conclude that "verbatim" compliance with Section III.O is expected. Any leakages which are not contained by the lube oil collection system appear to be a violation of Section III.O unless the "leakage" was previously identified and determined to not adversely affect the operability of safety-related equipment. This evaluation would most likely need to be reviewed and approved by the NRC as an exemption/deviation to Section III.O requirements.

Several licensees have a concern with loss of oil inventory due to normal lube oil system operation. For example, oil that is "sprayed" onto nearby equipment due to normal motor turbulence during operation may not necessarily get caught into the drain pans or contained in the lube oil collection system. Ft, Calhoun has recently evaluated this condition in a white paper and determined that the oil loss is not significant and will not affect the ability to safely shutdown. It is not clear whether this is considered a "leak" of the lube oil system. The rule implies that the collection system is to accommodate any "leaks" from the entire lube oil system inventory. Millstone Unit 2 received a Severity Level IV violation for "leaks" from the oil system (approximately one gallon) were not collected and drained to a closed container. The uncollected oil was found near hot RCS piping and was considered to be a fire hazard concern. Therefore, although the loss of oil is not termed a "leak", a tire protection engineer will need to determine if the loss of oil is a fire hazard. However, it appears that a licensee may risk receiving a violation from Section III.O requirements if this type of loss was not previously evaluated and accepted by the NRC via an approved exemption/deviation.

Seismic Qualification of the Lube Oil Collection System

As discussed earlier, the intent of Section III.O is to ensure that lube oil is confined in a containment in the event of a Safe Shutdown Earthquake such that a fire hazard that would affect operability of safety-related equipment is precluded. In 1984, Wans Bar received a Severity Level IV violation for failure to have a collection system withstand the SSE. Several licensees have identified piping in their lube oil system which is not seismically qualified, and have evaluated acceptability of oil leakage upon failure of the piping due to seismic activity (e.g., Haddam Neck, Millstone Unit *2,* and Prairie Island). The safety evaluation for Haddam Neck and Millstone was based on having the lube oil system seismically qualified such that oil leaks are not expected as a result of an SSE and that even if it did leak, a fire would not occur and not affect safety related equipment. Similarly with Prairie Island, the safety evaluation determined that the oil that would leak from the non-seismic category piping would not affect safety-related equipment

The review has determined that if the lube oil collection system is not qualified to withstand an SSE, then an exemption/deviation would need to be obtained. Generic Letter 86-10 provides guidance on acceptable alternatives. Technical basis for the exemption/deviation should include a discussion of the effects of oil leaking from the non-qualified piping and the affects of the oil on safety-related equipment. As discussed further below, the technical basis should also consider the impact on the ability to achieve and maintain safe shutdown due to leakage from the non-qualified piping. If the lube oil system is seismically qualified, then random oil leaks from the joints are postulated. For these cases, the lube oil collection system may not have to be qualified, and this condition would need to be reviewed and accepted by the NRC under the exemption/deviation process.

Lube Oil Collection Inventory

Based on reviewing the evolution of guidance documents related to the regulation, it appears that the inventory of the lube oil collection tank was not clearly understood. The rule requires that the container hold the "entire lube oil system inventory". This implies that container can hold lube oil from all reactor coolant pumps. Several licensees received violations during the early years of Appendix R reviews (e.g., Trojan and Davis-Besse). Guidance provided in NRC letters (e.g., St. Lucie, Information Notice 84-09) appear to be adequately indicate the NRC's position that the lube oil collection system contain the entire inventory of the lube oil system. Several licensees have approved exemptions/deviations for providing a collection tank that will contain less than the entire lube oil inventory (e.g., Diablo Canyon, Trojan, Davis-Besse, Indian Point 2, Surry Unit 1, Waterford 3 and Indian Point 2). In 1982, both Big Rock Point and La Crosse were granted exemptions for not providing a lube oil collection system because the amount of oil in the motors (31.75 gallons and 15 gallons, respectively) were enclosed in the motor housing and would not result in a significant fire

hazard to affect safety related equipment. If the lube oil collection system is determined to not be able to contain the entire inventory of the lube oil collection system, then an exemption/deviation to this specific Section III.O requirement would need to be obtained (Ref. Info Notice 84-09). Safety analyses for oil overflowing from the collection tank have credited flow into the containment sump, flow into an area without ignition sources, flow into an area where there are no safety-related equipment, or flow into another container that will not endanger safety-related equipment. If the oil inventory is determined to be low enough such that a fire hazard to safety related equipment is not credible, then a collection system may not need to be provided. An exemption/deviation from Section III.O will still be required.

Safety Analyses

The safety analysis for most exemptions includes an evaluation of the affects of the oil leaks on the operability of safety-related equipment. In a couple SERs, the NRC has re-emphasized that the underlying purpose of the rule is to accomplish safe shutdown in the event of a single fire and maintain the plant in a safe shutdown condition (e.g., Ft. Calhoun and Surry Unit 1). This has been interpreted by some licensees as an acceptance criteria when re evaluating the design of the lube oil collection system. In general, demonstrating the ability to achieve and maintain safe shutdown conditions in the event of a fire provides assurance that the health and safety of the public is not at risk. However, all licensees still have a commitment to meet Section III.O regardless if the ability to achieve and maintain safe shutdown can be demonstrated.

Generic Letter 86-10 allowed licensees to revise their license condition to the standard condition which states the following (or similar):

> "The licensee may make changes to the approved fire protection program without prior approval of the Commission only if those changes would not adversely affect the ability to achieve and maintain safe shutdown in the event of a fire."

Licensees who have adopted this license condition may make the mistake of evaluating the acceptability of leakages not contained by existing lube oil collection systems, and conclude that prior approval of the Commission would not be required. Section III.O is *very* specific. A lube oil collection system that does not comply with the requirement "verbatim" would be in non-compliance with the rule. "Waterford 3 just recently submitted an exemption request for not complying verbatim with Section III.O.

As part of the technical basis for acceptability of leakages that are not contained by the lube oil collection system, an evaluation should be performed on the impact on the ability to achieve and maintain safe shutdown. If the criteria of Section III.G of Appendix R is met in Containment (or in another fire area being evaluated), then the ability to achieve and maintain safe shutdown is assured. Credit could also be taken for the technical basis of approved exemptions/deviations from Sections III.G for the fire area. Separation requirements of Section III.G.2.b require that redundant circuits for equipment credit for hot shutdown can be separated by a horizontal distance of 20 feet with no intervening combustibles and hazards, in addition to installation of an automatic detection and suppression system. In containment, most licensees would credit this method of separation for redundant safe shutdown circuits. The evaluation should ensure that the oil leak will not become a hazard and affect the separation of redundant safe shutdown circuits.

Nearby ignition sources or hot pipes and available suppression and detection systems should also be considered in the safety analysis. The main concern is the occurrence of a fire. Part of the defense-in-depth philosophy includes controlling combustible materials and ignition sources to prevent

initiation of a fire. The oil leaks should be reviewed to determine if contact with high-temperature sources is credible. The defense-in-depth philosophy also takes credit for the available fire protection features in the area. A seismically qualified sprinkler system and/or detection system over the postulated leakage areas will provide assurance that a postulated fire would be promptly identified and suppressed.

4. **Conclusion**

Based on this licensing review, it appears that if a licensees lube oil collection system does not comply with the literal requirements of Section III.O, an exemption/deviation will need to be approved by the NRC. Literal compliance involves having a lube oil collection system which meets the following:

> designed, engineered and installed so that failure will not lead to a fire during normal or design basis accident conditions,
> qualified to withstand a safe-shutdown earthquake,
> capable of collecting lube oil from all pressurized and unpressurized leakage sites into a vented closed container capable of holding the entire lube oil system inventory
> container is provided with a flame arrester in the vent if fire flashback is credible
> contain oil leaks from the lift pump and piping, overflow lines, lube oil coolant, oil fill and drain lines and plugs, flanged connections on oil lines and lube oil reservoirs
> provided with a drain line that is large enough to accommodate the largest potential oil leak

If the lube oil collection system does not meet the above criteria, then an exemption or deviation from the rule would need to be obtained. The technical basis for the exemption or deviation should take into consideration the impact on operability of safety-related equipment and on the ability to achieve and maintain safe shutdown conditions. The NRC has given violations to licensees for having collection systems which do not contain the entire inventory of the lube oil system. This includes leaks a small as one gallon and leaks which have soaked into insulation.

A recent fire at ANO Unit 1 has identified a new concern with oil that has been "atomized" in that ignition of the oil will occur at a much lower temperature than the postulated flashpoint and auto ignition temperature. To date, the NRC has not provided any guidance or position on this condition.

TABLE 1 - EVOLUTION OF RCP LUBE OIL COLLECTION SYSTEM REQUIREMENTS

70Date	Requirement	Technical Basis
May 29, 1980	*Section III.O Reactor Coolant Pump Lubrication System.* The reactor coolant pump lubrication system shall be protected by either an oil collection system or an automatic fire suppression system. Oil collection systems shall be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in the reactor coolant pumps' lube oil systems, and draining the oil to a vented closed container. A flame arrester is required in the vent if the flash point characteristics of the oil present the hazard of fire flashback. Leakage points to be protected shall include lift pump and piping, overflow lines, lube oil cooler, oil fill and drain lines and plugs, flanged connections on oil lines and lube oil reservoirs where such features exist on the reactor coolant pumps. Leakage shall be collected and drained to a closed container that can hold the en:ire lube oil system inventory, the drain line shall be large enough to accommodate the largest potential oil leak. To provide adequate protection for a design basis Safe Shutdown Earthquake (SSE), one of the following should be provided: 1. The lube oil system components whose failure could result in leakage should be designed to withstand an SSE without leakage and the dropping of oil collection system components during an SSE should not cause loss of operability of safety-related equipment; or *1*. The oil collection system should be designed to withstand an SSE and continue to be able to collect and drain leakage that may occur during an SSE. In this case, the oil collection system should be adequate to collect oil from any external lube oil piping not designed to withstand an SSE in addition to leakage from points identified above. If an automatic fire suppression system is selected, either the automatic and manual fire suppression system or the lube components whose failure could result in leakage should be designed to withstand the SSE.	The lubrication system for the reactor coolant pumps represents the largest single fire hazard inside containment. This item describes the arrangement of automatic fire suppression or oil collection systems that are to be provided for protection of this hazard.
Nov. 19, 1980	*Section III.O, Oil Collection System for Reactor Coolant Pump* The reactor coolant pump shall be equipped with an oil collection system if the containment is not inerted during normal operation. The oil collection system shall be so designed, engineered, and installed that failure will not lead	(p. 76603) "...as a result of its continuing review of fire protection matters the NRC staff has indicated to the Commission, that there are requirements in three sections in which protection afforded by Appendix R... may be desirable, the Commission has decided that these requirements should be retroactively applied to all facilities." "...The third relates to protection against fires in noninerted containments

TABLE 1 – EVOLUTION OF RCP LUBE OIL COLLECTION SYSTEM REQUIREMENTS

70Date	Requirement	Technical Basis
	to fire during normal or design basis accident conditions and that there is reasonable assurance that the system will withstand the Safe Shutdown Earthquake. Such collection systems shall be capable of collecting lube oil from all potential pressurized and unpressurized leakage sites in the reactor coolant pump lube oil systems. Leakage shall be collected and crained in a vented closed container that can hold the entire lube oil system inventory. A flame arrester is required in the vent if the flashpoint characteristics of the oil present the hazard of fire flashback. Leakage points to be protected shall include lift pump and piping, overflow lines, lube oil coolant, oil fill and drain lines and plugs, flanged connections on oil lines, and lube oil reservoirs where such features exist on the reactor coolant pumps. The drain line shall be large enough to accommodate the largest potential oil leak.	. involving reactor coolant pump lubrication oil...The proposed rule permitted either an oil collection system or a fire suppression system. The staff has also accepted an automatic fire suppression system as an acceptable method of fire protection for this application. The Commission has concluded that fire suppression systems do not give adequate protection for fires that may be induced by seismic events. The Commission therefore believes that previously approved suppression systems should be replaced with oil collection systems that can withstand seismic events." (p.76608) "Each reactor coolant pump motor assembly typically contains 140 to 220 gallons of lube oil. Oil leaking from some portions of the lube oil system may come in contact with surfaces that are hot enough to ignite the oil. The resulting fire could be large, and access to the fire would be delayed because of the time required to enter the containment. Containment air temperature would increase, severe localized environments would develop in the area of the fire, and a large amount of smoke would be generated. These conditions could affect operability of safety-related equipment inside containment. Therefore, an oil collection system is necessary to confine any oil discharged due to leakage or failure of the lubrication system and to prevent it from becoming a fire hazard by draining it to a safe location. These occurrences could be random or could be seismically induced because the existing lube oil system piping and oil collection systems may not be designed to withstand a design basis seismic event. "Appendix A to BTP APCSB 9.5-1 states that for operating plants, 'postulated fires or fire protection system failures need not be considered concurrent with other plant accidents or the most severe natural phenomena.' The basis for that statement is two fold. First, nuclear power plants are massive structures, and essential services are designed to withstand earthquakes and other natural phenomena. Second, the history of many fires associated with recent earthquakes have been evaluated. These evaluations showed that such fires usually are due to failure of piping or tanks of flammable gases or liquids such as municipal natural gas distribution systems or gasoline storage and/or dispensing stations. Where such potential fire hazards exist in nuclear power plants (e.g., hydrogen for generator cooling or oil fuel for the emergency diesel generator or station space heating boilers) they are designed and installed to withstand the damaging effects of

TABLE 1 - EVOLUTION OF RCP LUBE OIL COLLECTION SYSTEM REQUIREMENTS

70Dale	Requirement	Technical Basis
		various natural phenomena and other special fire protection features are provided as necessary. However, General Design Criterion 2 Design Bases for Fire Protection Against Natural Phenomena requires that structures, systems, and components important to safety be designed to withstand the effects of earthquakes without loss of capability to perform their safety function. Regulatory Guide 1.29, "Seismic Design Classification." describes an acceptable method for identifying and classifying those features of light-water-cooled nuclear power plants that should be designed to withstand the effects of the Safe Shutdown Earthquake. In this guide, paragraph C.I applies to systems that are required to remain functional to ensure heat removal capability; paragraph C.2 applies to systems that do not have to remain functional for that purpose, but whose failure could reduce the functioning of those systems covered by paragraph C.1. The reactor coolant pump collection system is covered by paragraph C.2 because its function is required to protect safety-related systems, rather than to perform a safety function (Regulatory Guide 1.29, "Seismic Design Classification." paragraph C.2), the oil collection system should be designed, engineered and installed so that its failure will not lead to a fire affecting safety-related equipment as a result of an earthquake. "The proposed rule permitted two alternatives--an oil collection system or an automatic fire suppression system. We have deleted the alternative of suppression system because unacceptable damage may result to the safety-related systems from the burning of oil before the suppression system is actuated and because the fire water supply system is not designed to withstand seismic events. In addition, these pumps are located within the biological shield inside containment, therefore, timely fire brigade action would be difficult if the suppression system malfunctions. Further, if the suppression system becomes inoperable during operation, a fire watch or patrol cannot enter the area during operation.

TABLE 2 - NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
Arkansas Nuclear One Unit 1 Arkansas Nuclear One Unit 2 (Entergy Operations)	In Dec, 1996, an exemption request was submitted for not having a oil leakage from the remote fill line collect into the collection system. The oil collection system was not capable of collecting lube oil from all potential unpressurized leakage sites, including oil fill lines. Original review of the design change to add the oil fill line connections incorrectly assumed that the oil fill lines were not part of the RCP lube oil systems.	On October 17, 1996, a fire was reported in the containment building, Investigation revealed that the fire was due to ignition of a fine mist of RCP lube oil on the RCP and piping in the general area. A cracked weld (circumferential and 270 degrees around the pipe) on a discharge line of the lift oil pump caused the spray during performance of a post maintenance test. Cleanup of the oil spray was limited to the immediate vicinity of the cracked weld. Oil was also sprayed onto the nearby "B" SG on approximately eight feet of 14-inch diameter piping on the external SG main feedwater ring. The oil seeped through the cracks between the stainless steel jackets and soaked the thermal insulation underneath. The section of pipe that failed was provided with an oil collection pan with drainage routed to the oil collection system. However, the pan was not designed to protect against a failure involving the welded connection. Due to the configuration of the oil spray, the oil spontaneously ignited even though the temperature is below the auto-ignition temperature. Two apparent violations were noted, but not sited (Insp. Report), An escalated enforcement action is being considered.
Big Rock Point (Consumers Power)	In April 1982, the NRC approved an exemption from III.O in that a lube oil collection system was not provided for their two RCPs. The exemption was approved based on the following: • Each RCP contains 31.75 gal of lube oil (1.75 gal in lower reservoir and 30 gal in upper) • All oil is con:ained within motor housing • A manually operated sprinkler system covers the area over the pumps and sump and is seismically qualified Calculation of worst-case fire estimated a temp rise of 163F.	
Calvert Cliffs Units I and 2 (Baltimore Gas and Electric)	In Nov. 1983, request for exemption for having lube oil collection tanks that could not accommodate leakage from two RCPs. The tank is capable of accommodating a leak from one	

TABLE 2- NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
	RCP (225 gal leak into a 275 gal tank). Technical justification includes: • oil spillage system for each RCP motor which consists of encapsulating devices installed around all potential leakage points. RCP oil collection system (except tank) are seismically qualified to withstand the SSE. • tanks vents ate equipped with flame arrestors • surveillance procedures to visually examine encapsulation devices, drain piping and oil collection tanks and level prior to startup • consequences of simultaneous release of all the oil from two RCP motors would not be significant from a fire standpoint (no ignition sources, no hot coolant piping, hangers or equipment, overflow from vent line to floor then flow into containment sump.	
Crystal River 3 (Florida Power Corp)	In Oct. 1994, an exemption was granted for the re-design of the lube oil collection system due to replacing existing RCP motors with a new motor. The re-design of the lube oil system is not able to accommodate four potential leakage sites because of physical interferences and other design difficulties. THE four potential leakage sites are: anti-reverse device (ARD) vents, upper oil supply lines from the lift pump to the ARD, lower motor leak detection system piping, and lower guide bearing thermocouple wells. (In the SER, the NRC states that "the underlying purpose of...III.O, is to establish an oil collection system such that lube oil leakage form potential pressurized and unpressurized leakage sites in the RCP lube oil system will not lead to fire during normal or deign basis accident conditions, and that there is reasonable assurance that the system will withstand the safe shutdown earthquake.:"" Evaluation of the four leakage points have determined that oil leaking from these systems may be exposed to hot RCS surfaces, but would not be hazard because of the high	On October 10, 1996, the oil collection system for RCP D was identified as not being capable of collecting the lube oil from all potential leakage points, in that the lower portion of the oil collection system was not properly installed following the 1996 refueling outage. This resulted in oil leaking from an improperly installed gasket seal on the bottom portion of the collection system and accumulating on the floor. The oil was not drained into the closed tanks where were designed for this purpose. A Severity Level IV violation was issued in Inspection Report 96-15, dated 11/27/96. Prior to this event, on May 15, 1995, a 10 CFR 5C.72 report identified that not all of the oil leakage from the RCPs was being collected by the lube oil collection system. The report identified that almost all of the approximately 115 gallons of ail added since June 1994 had not been recovered by the LOC system. Oil leaked from two paths: (1) thermocouple conduits not designed for oil submergence, and (2) pinhole

TABLE 2 - NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
	flashpoint temp and auto ignition temp. Additionally, if the oil leak ignited, the fire would be small, localized in the area of the leakage, promptly detected and mitigated.	leaks in the lower seam of the LOC sheet metal encapsulation boxes. On June 23, 1990, the LOC was improperly reassembled which resulted in the system not performing its intended function of collecting leakage from the lube oil system. A Severity Level 4 violation as received by Inspection Report 90-33 dated 12/7/90.
D.C. Cook (Indiana & Michigan Power Co.)		As of June 10, 1982, the design, engineering, and installation of the lubricating oil collection included a sight glass on the oil collection tank. The licensee could not provide reasonable assurance that the tank sight glass could withstand the Safe Shutdown Earthquake. Additionally, the oil collection tank was only large enough to hold approximately one-fourth of the entire lube oil system inventor for the 4 RCPs in each Unit. A Severity Level 3 Violation and an imposed penalty of $50K was received on March 6, 1991 {Inspection Report t 90-018 and 82-08).
Davis Besse (Toledo Edison)	In Aug. 1984, an exemption was approved for having an oil collection system that is not sized to hold the entire lube oil system inventory. The collection tank capacity can accommodate 250 gallons which can hold the total lube oil inventory of only one RCP motor in each loop with some margin. Any lube oil overflow will drain to the containment sump where there is no other flammable material or hot surfaces which may ignite the oil. Overflow of oil will not present an exposure hazard to or endanger safety-related equipment. In addition, the lube oil collection system is capable of withstanding the safe shutdown earthquake.	August 31, 1983 During an NRC inspection on July 1983, it was discovered that the RCP oil collection system was inadequate in that 2 RCPs, each with a lube oil capacity of approximately 225 gallons, were connected to into a single 250 gallon container. A Severity Level III Violation was received with a civil penalty in inspection report 33-16 {dated August 31, 1983). On Feb. 19, 1997, LER 97-0C4 reported that a portion of the RCP motor oil piping to the was outside the enclosure of the lube oil collection system. This additional piping included lower bearing remote oil fill connections, which are not pressurized; and piping for the lower bearing oil reservoir drains, which is exposed to only two feet static head pressure. The remote oil fill lines are designed to not trap any oil after use, and are not considered part of the RCP oil system. Therefore, the remote fill lines were not designed to meet the requirement that any potential oil leakage would be collected.

TABLE 2 – NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
Diablo Canyon Power Plant (Pacific Gas & Electric)	A deviation was approved for Units 1 and 2 to the extent that it requires that any overflow from oil collection ta.nk(s) be drained to a safe location when the collection system is designed to provide capacity to hold the lube oil inventory of one RCP with margin. The deviation credits the physical separation between the RCPs (by approx. 45 feet). The collection pans around each pump consist of metal fastened to the platform grating and all openings through and between the collection pans for conduit, pipes, and other such items are surrounded by drip shields draining to the collection pans. A skirt is also installed around the pump motor coupling to direct leaks on the outside of the motor casing to the collection pans below. The oil lift pump and piping are enclosed by a sheet metal shield, and spray from a potential oil lift pump leak would he confined within the shield and the spray oil directed to the collection pans. Leaks internal to the motor casing are diverted to the collection pans below by a gutter inside the coupling area or collected above the main pump flange which is surrounded by a 2-inch rim with an overflow drain to the collection pans. All joints are caulked to prevent leakage. Each collection pan is equipped with a drainpipe connected to a drain line. The drain lines for each pump are connected to a 2-inch common header which is routed to a collection tank. The tank is equipped with a valved drain, a 2-inch overflow and a 2-inch vent with a flame arrester. The tank is designed to contain the oil inventory of one RCP motor plus margin of 35 gallons. The overflow pipe discharges downward to *a* recessed trench in the floor which is sloped so that overflow of lube oil from an RCP pump would be to the containment sump. The overflow pipe is designed to withstand the safe shutdown earthquake. The deviation was approved based on the configuration of the lube oil collection system to handle any potential oil spills. The NRC also recognized that the flashpoint of 480 F would represent a significant hazard if atomized or if the oil came in contact with a high-energy	

TABLE 2- NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
	source. Because the oil collection system is designed to withstand a SSE and because there are no ignition sources in the anticipated flowpath of the overflowing oil, the NRC does not expect the oil to ignite.	
Ft. Calhoun (Omaha Public Power Dist)	In Dec. 1988, an exemption was granted for having a collection system that serves two pumps with only enough capacity for one pump (150 gal). The approved exemption described the unpressurized piping of the system is in the lower bearing and contains only four gallons per pump. The RCP oil collection system was reviewed and approved by the NRC in 1980. The lower oil reservoir does not have a collection system since it contains only four gallons, has an internal cooler, and there are no pressurized lines, sight glasses, etc. Also, the oil level transmitter is not contained since the transmitter housing has a pressure rating of 500 psig and is only exposed to 17 inches of oil. In addition, an analysis was performed showing that even if a fire occurred, the ability to safely shutdown would not be affected. (Note: In the SER, the NRC states, "In general, the underlying purpose of the rule is to accomplish safe shutdown in the event of a single fire and maintain the plant in a safe condition.") Under the worst case scenario, lube oil would overflow from the collection tanks and channeled to the floor drains. Since no ignition sources are present in the area, no fire is likely to occur. Therefore, the limited lube oil collection system capacity does not pose a significant hazard to safe shutdown systems. Further evaluation on the effects of a lube oil fire in the RCP cavities has shown that sufficient undamaged equipment would remain available to support safe shutdown.	In May of 1998 an exemption was approved for one RCPLOCS not fully covering certain components of a particular pump - unpressurized upper bearing cooling water penetrations, unpressurized lower bearing component cooling water penetration and an unpressurized vent line. This activity occurred after OPPD wrote a White Paper documenting the acceptability of approximately 10 gallons of oil loss in the motor housing due to normal system operation. The White Paper concludes that the "loose" oil will not pose an immanent fire hazard, and is not within the scope of III.O requirements.
Haddam Neck Millstone Station Unit 2 (Connecticut Yankee)	In Nov. 1981, the NRC approved for Haddam Neck and Millstone Station Unit 2, an exemption from I1I.O in that the lube oil collection system does not meet the SSE requirements and that a seismically qualified oil collection system would not enhance fire protection safety at the Haddam Neck Plant and Millstone Station Unit 2 because alternative means 10 fulfill the objective of the requirements have been	During Plant operation on July 11, 1994, the oil collection system installed on the RCPs at Haddam Neck did not meet the requirements of III.O in that it did not keep oil from a failed plastic coupling form coming in contact with the RCP insulation Further, the OCS did not collect oil from all potential leakage points (such as at the coupling and in the area of the oil lift pump). The inadequacies in the OCS

TABLE 2 - NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
	implemented. (In this SER, the NRC stated that "the oil collection system shall be so designed, engineered, and installed that failure will not lead to fire during normal or design basis accidents and that there is reasonable assurance that the system will withstand the Safe Shutdown Earthquake (SSE).") The approved exemption was based on: (1) having a lube oil system qualified to remain functional during and after seismic events up and including an SSE, and (2) the system would not cause loss of operability of safety related equipment nor would it cause a fire in the event of an SSE. Because of (1), oil leaks should not be expected as a result of an SSE, and because of (2), the lube oil systems for each plant would not degrade safety features within containment.	allowed oil leakage from a failed plastic coupling on the No. 3 RCP to come in contact with pump insulation, causing fires in the containment on July 11, 1994 and a similar event on July 14, 1993. A Severity Level IV violation was received in Inspection Report 94-18 dated 8/15/94.
Indian Point 2 (Consolidated Edison Co.)	NRC approved exemption in Jun. 1933 for having a lube oil collection system capacity (550 gal) less than the total lube oil inventory (1000 gal). The basis for the exemption is due to having a seismically qualified collection system that is capable of preventing the lube oil from contacting hot surfaces. Any oil leakage would be random and which may occur at pipe joints. Because of the small fire which would result from the limited leak, this configuration represents no significant fire hazard or endangerment to safety-related equipment.	
La Crosse BWR (Dairyland Power)	In Mar, 1982, the NRC approved the exemption for substituting the coupling oil with a non-flammable fluid, thus, reducing the combustible loading. This leaves approximately 15 gal of lube oil in containment for each of the two Forced Circulation Pumps. This low combustible loading will result in a small fire and not affect safety-related equipment.	
Millstone Unit 2 (Connecticut Yankee)	See Nov. 1981 NRC-approved exemption for Haddam Neck (above).	During Plant operation on July 27, 1994, the oil collection system installed on the RCPs at Unit 2 was not capable of collecting lube oil from the potential leakage sites because a total of approximately one gallon of lube oil leakage from the

TABLE 2 - NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
		A and D RCPs was not collected and drained to a closed container. The uncollected lube oil leakage found near hot RCS piping was a fire hazard concern. A Severity Level IV Violation was given in Inspection Report 94-28,94-27, and 94-24 on October 14, 1994.
Prairie Island Nuc Gen Sta (Northern States Power)	In July 1984, an exemption was approved for laving a lube oil collection system that is piped to the sump inside the containment. The contents of the sump can be pumped to a closed vented container located in the auxiliary building The sump is a concrete pit having a capacity of 990 gallons which is more than the capacity needed to contain the total inventory of lube oil for the two RCPs for each Unit. The basis for the design of this collection system is to collect any contaminated water from the pump seal leakage as well as any oil leakage. The piping from the sump to the vented container has been designed to seismic category class III, and part of the piping in containment is not Seismic Category I. Failure of the piping in containment would lead to lube oil returning to the sump area via drains, and failure of piping into he Auxiliary Building will contain oil within the immediate location which is separated from any safe shutdown equipment by concrete walls.	
San Onofre Nuclear Gen Sta (So. California Edison)		In Oct. 1996, SCE reported a condition in that oil leakage from a site glass (which is used to monitor level) was not covered by the existing lube oil collection system. Also, it was discovered that splash guards were not provided for all flange connections as committed
Surry Uni1 1 (Virginia Electric Power)	An exemption was granted in Dec. 1090, due to the original lube oil collection system not being able to accommodate a spare motor installed for one RCP while the original motor was removed for refurbishment. Therefore, an interim oil collection method in conjunction with other compensatory measures to mitigate the consequences should an oil fire occur. This exemption was valid through one operating cycle until the original motor is replaced. These measures involve detecting potential lube oil leakage by an increase in motor	

TABLE 2 - NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
	temperature and any leakage will be confined and contained in the RCP cubicle. The following interim modifications were made: • 4-inch oil tight dikes have been installed at door openings • pipes which penetrate the cubicle floor are sleeved and exposed pipes are either provided with a spray cover or penetration is filed with liquid tight fire rated sealant • heat detector installed above RCP motor • wall separates cubicle from adjacent areas. All penetrations are sealed • spray shields are installed to prevent high pressure oil spray from impinging on hot reactor coolant system (RCS) piping (In this SER, the NRC concluded that "based on our evaluation...we agree that if a lube oil system failure leading to a leak and subsequent fire were to occur in the C RCP motor, the consequences of the fire would be mitigated and the plant's ability TO achieve safe shutdown conditions would not be affected.")	
Three Mile Island Unit 1 (GPU Nuclear)	In Feb. 1990, exemption granted for having an oil collection system that was not capable of collecting lube oil from all potential unpressurized leakage sites including oil fill lines. The sloped remote fill piping is located over drip pans only at its extremities; the remote fill station and its termination at the oil reservoirs. Leakage/spillage contained by the remote fill station drip pan will not be directed to the RCP lube oil collection system by connecting piping. Design basis: • using welded joints at fill piping/tubing connections • slope piping/tubing • locate fill line connections above reservoirs high level alarm set point and overflow line • extend drip pans to collect possible leakage from	

TABLE 2- NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
	the sight glasses • confirm oil is not trapped in piping • procedures to require wipe up of any spillage at the remote fill station local drip pans	
Trojan Nuclear Plant (Portland General Electric)	In Mar. 1984, an exemption was granted for having a lube oil collection system that would be collected to a vented closed container. The oil collection system is seismically qualified, and a collection tank is provided for two RCPs. Any tank overflow would be to the immediate floor area and would be flow to drains routed to the Containment Building sump. Leakage points protected include the 4-in connections, drain plugs, fill points, upper and lower reservoirs, site glasses, lift pumps and external oil coolers. Any oil fire would he limited to small amount of residual oil that remains on pumps or collection system. surfaces and could be easily extinguished. It is unlikely any overflow from the collection tanks would come into contact with hot RCS surfaces since the tank is at a lower elevation than the RCPs and RCS surfaces in close proximity (viz. the steam generators and RCS cold leg piping) are thermally insulated. To ensure that overflow will not affect redundant safety-related equipment, a dike was provided around each collection tank to hold the oil inventory of all four motors.	During an inspection performed in June and July 1983, NRC inspectors discovered that two oil collection tanks had been installed, each with a capacity of 306 gallons. Each tank collects oil leakage from 2 RCPs. A reactor coolant pump lube oil system contains approximately 265 gallons of oil. Therefore, the potential lube oil leakage of two pumps into a tank exceeds collection capacity by approximately 224 gallons. This violation was part of a collective set of concerns and resulted in a Severity Level III violation with a civil penalty of $100K. PGE denied the violation and stated that the system the regulation was not clear in specifying a system to occupy all RCPs, but implied occupying one RCP.
Vermont Yankee Nuc Power	In Feb 1982, the NRC granted an exemption due to having an inerted Containment. III.O is required only if the containment is not inerted during normal operation.	
Waterford 3 (Entergy Operations)	An exemption was approved for having a lube oil collection tank capable of collecting oil leaks from pressurized and unpressurized leakage sites to a collection tank. Two oil collection tanks are capable of collecting 200 gallons each which will accommodate one RCP oil lube system (195 gals). An alarm will sound in the control room if significant amounts of oil is lost from the lube oil reservoirs. Each tank also has a glass liquid level gauge to provide local indication of existence of oil in the tank.	

TABLE 2 - NRC APPROVED EXEMPTIONS/DEVIATIONS AND RECENT REGULATORY ACTIVITIES

Licensee	Approved Exemption/Deviation	Recent Regulatory Activity
	In Feb. 1997, a request for an exemption was submitted for not having a the lube oil collection system cover the remote oil fill lines installed in 1986 and 1990. At the time of installation, review determined that the modification met the intent of Appendix R. However, recent reviews by the NRC have determined that while the design meets the intent of Appendix R, Section III.O, it is not in verbatim compliance with Appendix R. Addition of oil is administratively controlled via task cards and a procedure that controls the use of combustibles.	
Watts Bar (Tennessee Valley Authority)		During an NRC inspection on August 10, 1984, NRC inspectors discovered that with a containment not inerted during normal operations, the reactor coolant pump oil collection systems were not designed, engineered, or installed to withstand the safe shutdown earthquake. In addition, the drainage tank was not designed to hold the entire reactor coolant pump lube oil system inventory. This violation as was considered to be a Severity Level IV.